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Status of the Rocky and Little Rivers Stocks of Atlantic salmon (*Salmo salar* L.) of the Newfoundland Region in 1999

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Abstract

The status of Atlantic salmon in two systems, namely Rocky River and Little River are assessed. The 1999 escapement to Rocky River was 404 (327 small and 77 large) salmon which was 166% and 104% of the 1987-91 and 1992- 1998 means, respectively. The 1999 escapement to Little River was 356 (307 small and 49 large) salmon which was 375% and 118% of the 1987-91 and 1992- 1998 means respectively. Egg deposition for each watershed was 39% for Rocky River, and 38%(preliminary due to fry stocking) for Little River of the required conservation egg deposition. The 1999 Rocky River smolt count of 8,625 is below the 1990-98 mean of 9,825 with sea survival to 1SW salmon being 1.79%, the lowest in the nine year series. The 1999 Little River smolt count of 1,177 is below the 1992-98 mean of 2,030.

Résumé

L'état du saumon de l'Atlantique est évalué dans deux réseaux, notamment celui de Rocky River et Little River. En 1999, l'échappée vers Rocky River comportait 404 saumons (327 petits et 77 gros), correspondant respectivement à 166 et à 104 % de la moyenne des échappées de 1987 à 1991 et de 1992 à 1998. L'échappée vers Little River en 1999 était constituée de 356 saumons (307 petits et 49 gros), représentant respectivement 375 et 118 % de la moyenne des échappées de 1987 à 1991 et de 1992 à 1998. La ponte atteignait respectivement 39 % pour Rocky River et 38 % (chiffre provisoire en raison de l'alevinage) pour Little River de l'objectif de conservation requis. Les saumoneaux dénombrés dans Rocky River en 1999 (8 625) étaient moins nombreux que la moyenne de 9 825 de 1990-1998, avec un taux de survie en mer des saumons unibermarins de 1,79 %, le plus faible dans la série de neuf ans. Les saumoneaux dans Little River se chiffraient à 1 177 en 1999, soit en bas de la moyenne de 2 030 établie pour les années 1992-1998.

Introduction

The watersheds discussed in this paper have all undergone enhancement/fry stocking activities.

Rocky River, in SFA 9 was the site of a colonization project where a run of Atlantic salmon was established. Little River, in SFA 11 is the site of an ongoing ranching project with associated fry stocking.

The intent of this document is to review the status of Atlantic salmon stocks in the Rocky River and Little River watersheds in 1999.

Methods

Biological Characteristics

Biological characteristics used in this document are those determined for individual stocks (see Tables 2,3,7, and 10).

Habitat Determinations

Rocky River, the largest watershed on the Avalon Peninsula, encompasses a drainage area of 296 km^2 (Porter et al. 1974) flowing to the sea in Salmon Fishing Area 9 (SFA 9) (Fig. 1). Prior to fishway construction in 1987, a natural falls at the mouth of this river, made this watershed inaccessible to anadromous Atlantic salmon. Rocky River requires 3.4 million eggs to meet the required conservation egg deposition (Table 1).

The Little River flows into the Bay d'Espoir in SFA 11(Fig. 1) approximately 4 km south of the Conne River. The watershed encompasses 183 km^2 (Porter et al. 1974) with a complete obstruction at kilometre 4.8 on the main stem of the river which results in anadromous Atlantic salmon having access to less than 30% of the watershed. Little River requires 313,920 and 976,072 eggs for the accessible and inaccessible portions of the watershed for conservation (Table 1).

Enhancement/Stocking Activities

The Rocky River was stocked with unfed fry from a controlled flow spawning channel from 1984 to 1987; unfed fry from 1995 to 1996 from a recirculation incubator; 90 day fingerlings from the latter source in 1995 and adult salmon in 1987. For the stockings from 1984 to 1987 the brood source was Little Salmonier River. For additional detail on stocking activities refer to Table 4.

Little River was stocked with unfed fry from 1989 to 1999 with the exception of 1995 and 1998. Eggs from Little River were incubated in deep substrate incubation boxes and in recent years in fiberglass troughs. For additional detail on stocking activities refer to Table 8.

Recreational Fishery

Rocky River, since the introduction of anadromous Atlantic salmon, has not been open for a recreational salmon fishery.

Little River downstream of the obstruction has been closed to angling since 1989.

Management Measures

Management restrictions implemented in 1992 that impacted marine exploitation of salmon are as follows:

1. Moratorium on commercial salmon fishing along the coast of insular Newfoundland.

2. Moratorium on the cod fishery in areas 2J, 3K and 3L implemented on July 15, 1992. In 1998 a limited inshore index cod fishery was permitted in Sept. – Oct. and in 1999 a limited 9,000 t (total allowable catch) fishery was permitted.

3. Moratorium on the cod fishery in SFAs 10-14A implemented in August of 1993 further reduced the by-catch of Atlantic salmon. In 1997 the cod fishery in SFAs 10 and 11 reopened with a TAC of 10,000t: the quota was incresed to 20,000 t in 1998 and 30,000 t in 1999.

Fecundity

Detail of a fecundity study conducted on Rocky River is in the following table:

Year	Number of females examined	Number of females examined for egg retention
1994	19	19
1995	30	5

Female salmon examined for fecundity were sampled for fork length, whole weight and scale sampled. Fish were manually stripped of their eggs, fertilised and then counted directly. Fish examined for egg retention were sacrificed and any remaining eggs removed, kept separate, fertilised and then counted directly. Percentage of eggs retained were used to adjust the egg counts of fish that were released alive.

The authors have chosen to utilise a length-based relationship to determine egg deposition as fish length records are likely more accurate than fish weight records. An analysis of covariance revealed a significant relationship between the length of female fish and number of eggs ($p < 0.05$); however, no significant relationship was found with

year. As a result of this analysis of covariance, fecundity data from the two years were combined. Regression analysis of raw, and log transformed data revealed significant relationships for both and provided R^2 values of .57 and .56, respectively. Figure 2 displays the regression line and equation for the linear regression of total number of eggs on fish length.

The Rocky River egg deposition was calculated based on average number of eggs/cm of fish (female) fork length. Percentage females in the population was calculated using the sex ratio of broodstock for the particular year and mean weight of females collected from broodstock. Rocky River egg deposition in 1996-1998 was based on the combined fecundity data for 1994 and 1995 years.

Fecundity values for Little River are those determined for the Conne River in 1993.

Egg Depositions

The conservation egg requirement was calculated based on 2.40 egg/m^2 of fluvial habitat and 368 eggs/ha of standing water. Smolt production of 7 smolt/ha was divided by 1.9% to convert this to eggs, (O'Connell et al., 1991).

Egg deposition was calculated by solving the linear regression equation using mean length of female salmon.

In order to determine the egg deposition in areas where fry stocking occurred, an estimate of egg-to-fry survival of 20% (Sturge, 1968) was used to back-calculate the number of fry released to equivalent naturally spawned eggs. Sturge (1968), in his work, gave a range of 10-30% for egg-to-fry survival and indicated that a figure of 20% appeared to be a reasonable value. Parr were back calculated to eggs by dividing the number of parr stocked by 0.125(V. Pepper, pers. comm.) based on parr stocking data obtained from Black Brook. Assumptions are that natural egg to fry survival is 20% and that 40% of the wild fry survive to their first fall. Inherent in this calculation is that 80% of fry placed in grow out cages survive to 90 day fingerlings.

Spawning escapements were calculated from fishway/fence counts less known removals with a 10% mortality rate applied to hook-and-released salmon.

Smolt Operations

In 1999, a smolt fence was operated on the Rocky River for the tenth year; Dates of operation and dates of first and last smolt listed below.

Year	Dates of Operation	Date of First Smolt	Date of Last Smolt
1990	Apr. 26 - June 8	Apr. 27	June 8
1991	Apr. 23 - June 19	May 1	June 19
1992	Apr. 27 - June 16	Apr. 29	June 15
1993	Apr. 28 - June 14	May 4	June 11
1994	Apr. 29 - June 16	May 1	June 16
1995	May 2 - June 14	May 2	June 14
1996	Apr. 25 - May 22	Apr. 26	May 22
1997	May. 5 - June 23	May 6	June 23
1998	Apr. 24 – June 15	Apr. 26	June 15
1999	Apr. 18 – June 14	Apr. 20	June 14

The Rocky River smolt fence operated from April 18 – June 14 during 1999 with the exception of one 86.5 hour period when rods were removed due to high water and associated debris. Rods were removed on April 28 at 2030 hours and the fence was operational at 1100 on May 2. Prior to removing rods on April 28 the daily count was 74 smolt; the adjustment for April 28 was to increase the daily total by 15%. The adjusted count for April 28 was then used for April 29 – May 1. The count for May 2 from 1100 – 2400 was doubled to adjust for the period 0000 – 1100.

A smolt fence has operated on the Little River since 1992 and from April 19 – June 9 in 1999.

Smolt that were sampled had the following data collected; fork length, whole weight, scale sample and sex.

Smolt condition was calculated as weight/length^3.

Adult Counts

In 1999, as in past years, a trap was installed in the upper most pool of the Rocky River fishway which, was operated from June 28 – Sept.22.

An adult counting fence operated on Little River from June 2 – Oct.13 in 1999.

Smolt to adult survival

Smolt to adult survival was calculated based on the portion of virgin 1 SW fish in the escapement. This was determined by removing the repeat spawners from the fish enumerated based on scale aeging.

Fin-clipped smolt

As part of the 1995 enhancement activities on Rocky River, 50,000 fry were raised for 90 days in semi-natural conditions resulting in the release of 31,983 parr that were adipose fin-clipped. Evaluation of the 2^+ component of this stocking was undertaken in 1997 in part through the examination of 30% of the run for the presence of adipose fin-clips. Evaluation of the 3^+ component of this stocking was undertaken in 1998 in part through the examination of 28% of the run for the presence of adipose fin-clips. Evaluation of the 4^+ component of this stocking was undertaken in 1999 in part through the examination of 24% of the run for the presence of adipose fin-clips.

Spawning Distribution

In 1999 a redd survey was conducted on Rocky River to determine the spawning distribution of the adult fish.

Results and Discussion

The use of fixed parameters, such as 2.4 eggs m^2 and 7 smolts/ha of standing water, has certain limitations (see O'Connell & Dempson, 1995 for discussion on this topic).

Rocky River

Egg Deposition

The 1999 freshwater escapement (total returns) of 404 (327 small and 77 large) adults to Rocky River was 166% of the 1987-1991 mean and 104% of the 1992-1998 mean. In 1999 Rocky River achieved 39 % of it's conservation egg deposition (Table 4.).

Smolt Count

In 1999, 8,321 smolt were enumerated in a partial smolt count; the adjusted smolt count was 8,625. Adjustments made included 304 smolt for the April 28-May 2 washout.

This count (see Table 5) is 88% of the 1990 - 1998 mean smolt count. The 1999 smolt run was comprised of 1% age 2^+, 77% age 3^+, 20% age 4^+ and 1% age 5^+ smolt (from the 1993 - 1997 egg depositions) (Table 3).

Smolt-to-Adult Survival

Figure 3 displays smolt-to-adult survival from 1990-1998 which averaged 2.8% and ranged from 1.79% to 4.2%. In 1998 smolt-to-adult survival decreased to 1.79% and was the lowest value for the years when data are available. Table 5 details enumeration of the 1990 - 1999 smolt output. The 1999 adult returns were resultant from natural spawning and parr stocking in 1995 and 1996.

Figure 3 also displays the relative condition factor of the outmigrating smolt which was one of the highest values observed in 1997 but yielded the lowest smolt-to-adult survival rates observed to date.

Figure 4 reveals the relationship between virgin 1SW returns plotted against smolt condition.

Egg-to-Smolt survival

Table 6 provides insight into the egg/fry-to-smolt survival on the Rocky River. At present it appears that egg-to-smolt survival has been improving since 1990 with the 1992 and 1993 egg depositions yielding the highest egg-to-smolt survival figures recorded to date.

Spawning Distribution

The results of this survey revealed redds distributed throughout the system and all tributaries being utilized for spawning. Adult fish have access to the entire watershed with no clumping of spawners in particular areas.

Parr Rearing

In 1997- 1999 river age 2^{+} - 4^{+} smolts from the 1995 stocking of 31,983 reared parr were examined for survival yielding the following results;

Year	% of smolt run examined	No. of fin-clips observed	Estimated no. of fin-clips
1997	32.8%	765	2,332
1998	25.6%	608	2,375
1999	24.8%	32	129
Total			4,707

These smolt had an average mean length and weight that was larger than the average for the wild smolt run (see Table 3).

Survival, to date, from fry and 1^{+} parr to smolt was 9.4% and 14.7% respectively for the 90 day fingerlings.

Predicted adult returns

Forecasts in terms of virgin grilse returns in year X + 1 have been made since 1994 for Rocky River and are listed in the text table below. Forecasts were made based on the range of smolt-to-adult survivals observed to date.

Year	Prediction	Observed
1999	268-511 virgin grilse	218 virgin grilse
1998	410-740 virgin grilse	370 virgin grilse
1997	300-496 virgin grilse	353 virgin grilse
1996	189-323 virgin grilse	314 virgin grilse
1995	234-318 virgin grilse	324 virgin grilse

Little River

Table 1 details the available habitat and the required egg deposition for the Little River watershed. The data are presented for the area above and below the obstruction since fry stocking occurs above the falls. In 1999 a fence count of 356 (307 small & 49 large) adults was recorded. The 1999 returns are 374% of the 1987-1991 mean and 118% of the 1992-1998 mean.

In 1999 Little River achieved 38% of it's required conservation egg deposition (see Table 8). Note figure is preliminary due to fry stocking.

Table 9 details the dates of counting fence operation and the number of smolt and parr enumerated for 1992 - 1999. Table 10 details the biological characteristics of smolt sampled in Little River. Of interest is the large number of parr enumerated at the fence each year. The fence site is located approximately 1 km upstream of the river mouth but is under tidal influence. This is suggestive that these parr are smoltifying downstream of the fence site.

In 1999, five salmon of hatchery origin were identified from Little River.

Smolt-to-adult survival figures were not calculated as they would not likely be indicative of the entire smolt output.

There were no fry were stocked in Little River in 1998.

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Table 1: Rearing area and conservation egg deposition for watersheds referenced in present study.

	Riverine habitat (m^2)	Lacustrine habitat (ha)	Conservation egg deposition
Rocky River	10,823	2,191	3,404,730
Little River	5,221	989	1,253,040
-accessible	1,308	0	313,920
-inaccessible	3,913	989	939,120

Table 2. Biological characteristics of Rocky River adults.

Year	No. Sampled	% Female	No. 2 Sea Winter Virgin	Mean Length(cm)	Mean Weight(kg)	% Repeat Spawners	Freshwater Age 2^+	3^+	4^+	5^+
1990	21	N/A	0	57.1	2.2	14	6	72	16	6
1991	32	N/A	0	56.9	2.2	9	15	58	27	0
1992	24	N/A	0	58.0	2.4	17	18	55	27	0
1993	32	N/A	0	56.5	2.2	13	3	69	24	3
1994	68	79	0	56.9	2.0	31	16	72	12	0
1995	111	86	1	56.0	2.0	22	14	77	9	0
1996	18	N/A	0	54.9	2.0	17	6	61	33	0
1997	41	N/A	1	59.6	2.5	34	13	85	2	0
1998	38	N/A	1	57.5	2.3	26	3	90	5	2
1999	32	N/A	0	57.1	2.3	41	20	44	36	0

Table 3 . Biological characteristics of Rocky River smolt.

Year	No. Sampled	% Female	Mean Length(cm)	Mean Weight(g)	Percentage at various Freshwater Ages				
					2^+	3^+	4^+	5^+	6^+
1988	28	57.1	17.5	54.5	0	64	36	0	0
1989	28	N/A	14.9	32.4	18	67	11	4	0
1990	101	84.2	17.3	46.5	1	66	29	4	0
1991	146	86.3	17.0	43.2	16	70	13	1	0
1992	71	78.9	17.0	44.7	1	76	21	2	0
1993	88	71.6	18.9	58.2	13	57	24	6	0
1994	160	83.8	17.0	45.1	2	66	29	3	0
1995	124	77.4	17.0	44.8	16	77	7	0	0
1996	203	83.4	16.7	44.1	7	82	10	0	1
1997	110	75.5	17.2	46.3	11	76	13	0	0
Finclip	116	56.3	17.5	49.1	100	0	0	0	0
1998	119	55.7	17.0	44.1	27	62	9	2	0
Finclip	90	55.0	18.1	54.2	0	100	0	0	0
1999	193	77.6	17.3	50.8	1	79	19	1	0
Finclip	3	?	18.7	61.0	0	0	100	0	0

Table 4. Details of egg deposition Rocky River.

Year	Fry Stocked	Parr Stocked	Adults Stocked	Adult Count			Broodstock	Total Eggs	% Conservation Egg
				Total	Small	Large			
1983	0		0				0	1,538,875	45
1984	307775		0				0	2,172,500	64
1985	434500		0				0	970,000	29
1986	194000		0				0	1,998,225	59
1987	399645		140	81	80	1	0	743,595	22
1988	0		0	319	313	6	0	1,011,527	30
1989	0		0	177	168	9	0	561,255	17
1990	0		0	418	401	17	0	1,359,420	40
1991	0		0	227	211	16	0	730,874	22
1992	0		0	283	237	46	0	961,811	28
1993	0		0	364	292	72	0	1,148,320	34
1994	0		0	177	158	19	62	857,862	25
1995	50,000	31,983	0	424	385	39	76	1,918,012	56
1996	162,231	0	0	401	356	45	0	1,163,295	34
1997	0	0	0	524	435	89	0	1,917,225	56
1998	0	0	0	553	423	130	0	1,834,473	54
1999	0	0	0	404	377	77	0	1,340,193	39

-The 1998 biocharacteristics for Rocky River egg deposition are the same as those used for 1996.

Table 5. Details of smolt enumeration Rocky River 1990-1999.

Year	Smolt Count	Smolt Released	% Smolt-to-1SWAdult Survival
1990	8287	8287	2.47
1991	7732	7732	2.93
1992	7813	7813	3.49
1993	5115*	5115	2.30
1994	9781	9781	3.39
1995	7577	7577	4.15
1996	14,261*	13,057	2.8
1997	16,900*	16,900	2.19
1998	12,163*	12,163	1.79
1999	8,625*	8,436	

* Smolt count is an estimate due to fence washout

Table 6. Details of egg/fry to smolt survival for Rocky River.

Year	egg to smolt survival (%)	Fry to smolt survival (%)	Smolt classes
1985		0.08	5^+
1986		1.3	4^+ , 5^+
1987		1.6	3^+, 4^+ , 5^+
1987	1.00		2^+, 3^+, 4^+, 5^+
1988	0.86		2^+ ,3^+ , 4^+, 5^+
1989	1.04		2^+ , 3^+,4^+, 5^+
1990	0.57		2^+, 3^+, 4^+, 5^+
1991	1.02		2^+, 3^+, 4^+, 5^+
1992	1.62		2^+, 3, 4^+, 5^+
1993	1.28		2^+, 3^+, 4^+, 5^+
1994	1.31		2^+, 3^+, 4^+
1995	0.52		2^+, 3^+
1996	0.01		2^+

Table 7. Biological characteristics Little River adults 1990, 1992 – 1996, 1998.

Year	Life Stage	Fork Length			Weight			River Age		
		Mean (No.)	S.D.	Range	Mean (No.)	S.D.	Range	Mean (No.)	S.D	Range
1990	1SW	51.41 (73)	3.79	44.00-62.80	1.34 (73)	.32	.700-2.500	3.02 (62)	.50	2-4
	Repeat	57.40 (4)	1.19	56.20-59.00	1.82 (4)	.15	1.700-2.000	3.00 (4)	.00	3
1992	1SW	51.51 (89)	2.53	46.50-59.00	1.48 (88)	.22	1.100-2.200	3.00 (68)	.42	2-4
	Repeat	63.85 (12)	6.45	53.50-73.00	3.05 (11)	1.20	1.700-5.900	2.80 (10)	.42	2-3
1993	1SW	51.68 (154)	2.81	40.90-59.10	1.486(154)	.29	1.000-2.700	3.05 (144)	.38	2-4
	Repeat	60.55 (13)	5.62	53.70-72.70	2.29 (12)	.65	1.400-3.800	2.92 (12)	.29	2-3
1994	1SW	51.33 (62)	2.93	41.80-60.20	1.33 (62)	.25	.800-2.200	2.95 (58)	.35	2-4
	Repeat	58.19 (8)	7.42	48.70-71.00	1.97 (8)	.82	1.300-3.600	3.14 (7)	.69	2-4
1995	1SW	51.17 (111)	3.34	44.70-67.60	1.25 (111)	.26	.800-2.900	2.86 (108)	.50	2-4
	2SW	68.00 (1)	-	-	3.00 (1)	-	-	-	-	-
	Repeat	61.81 (7)	5.49	55.50-70.80	2.24 (7)	.71	1.500-3.300	3.00 (7)	.58	2-4
1996	1SW	53.12 (113)	2.23	46.00-58.70	1.41 (113)	.21	.960-2.120	2.60 (110)	.60	1-4
	Repeat	66.50 (1)	-	-	1.58 (1)	-	-	-	-	-
1998	1SW	51.5(105)	4.32	42.4-69.8	1.40(105)	.36	.800-3.65	3.17(104)	.49	2-5
	Repeat	66.7(49)	5.62	56.0-79.6	3.06(50)	.78	1.65-4.7	2.68(50)	.68	2-4
1999	1SW	53.75(69)	3.01	47.4-60.1	1.5(69)	.29	.89-2.2	2.71(69)	.65	2-4
	Repeat	66.35(250	6.91	55.2-77.8	2.7(25)	1.0	.48-4.4	3.14(21)	73	2-5

Table 8. Egg deposition rates for Little River 1987-1995.

Year	Fence Count		Spawning Escapement	Stocking		Natural Egg Deposition	% Conservation Wild Below Falls	Total Eggs	% Conservation Total
	Small	Large		Fry	Egg Equivalents				
1987	64	3	67	0	0	91,410	29%	91,410	7%
1988	65	3	68	0	0	92,774	29%	92,774	7%
1989	102	5	64	0	100350	90,046	28%	190,396	15%
1990	158	15	93	20070	204835	124,154	40%	328,989	26%
1991	55	6	31	40967	103715	42,294	14%	146,009	12%
1992	104	21	26	20743	656215	35,473	11%	691,688	55%
1993	169	11	75	131243	592360	102,325	80%	694,685	55%
1994	73	11	84	118472	0	114,604	37%	114,604	9%
1995	118	17	45	0	462640	61,395	56%	524,035	42%
1996	674	127	663	92528	729605	904,551	288%	1,634,156	130%
1997	399	79	461	145921	0	633,049	200%	633,049	51%
1998	264	49	116	0	1530900	158,262	50%	1,689,162	135%
1999	307	49	88	306180		118,541	38%		

Egg deposition for 1999 is preliminary due to fry stocking to be conducted later this year

Table 9. Details of smolt and parr enumeration Little River.

Year	Dates of Operation	No. Smolt	No. Parr
1992	May 11-July 5	382	1,404
1993	May 15-July 5	324	1,500
1994	May 6- June 13	501	4,018
1995	May 2 – June 22	2,712	1,586
1996	May 1 – June 5	4,449	585
1997	May 14 - July 8	2,521	336
1998	Apr. 25 – June 16	3,320	739
1999*	Apr. 19 – June 9	1,117	171

* the fence was out of operation from Apr.29 – May 3

Table 10. Biological characteristics of Little River smolt.

Year	No. Sampled	% Female	Mean Length(cm)	Mean Weight(g)	% at Age		
					2^+	3^+	4^+
1993	43	97.7	17.58	50.73	32.6	58.1	9.3
1995	31	87.1	14.86	26.87	90.3	9.7	0
1996	51	94.1	16.16	39.40	5.9	90.2	3.9
1997	79	85.7	15.69	41.62	23.1	71.8	5.1
1998	49	75.5	15.36	34.02	45.8	45.8	6.3
1999	42	81.0	15.87	37.73	31.0	64.3	4.7

Note: 1993 & 1995 smolt samples were collected on a single day.
1996 samples collected over 5 days.
1997 samples collected May 22 - June 11
1998 samples collected May
1999 samples collected May 11- May 25

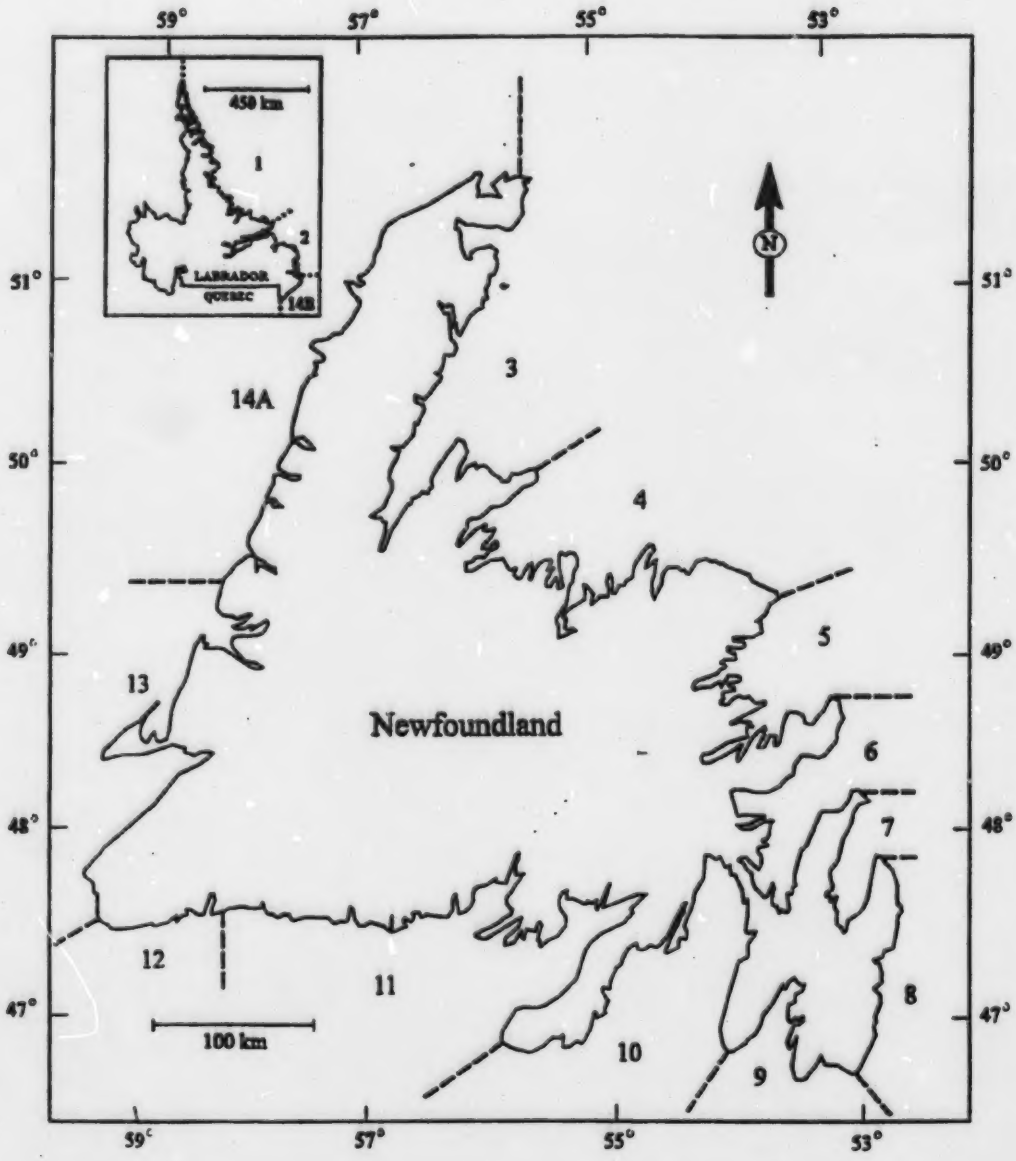

Fig. 1. Map showing the 14 Salmon Fishing Areas of the Newfoundland Region.

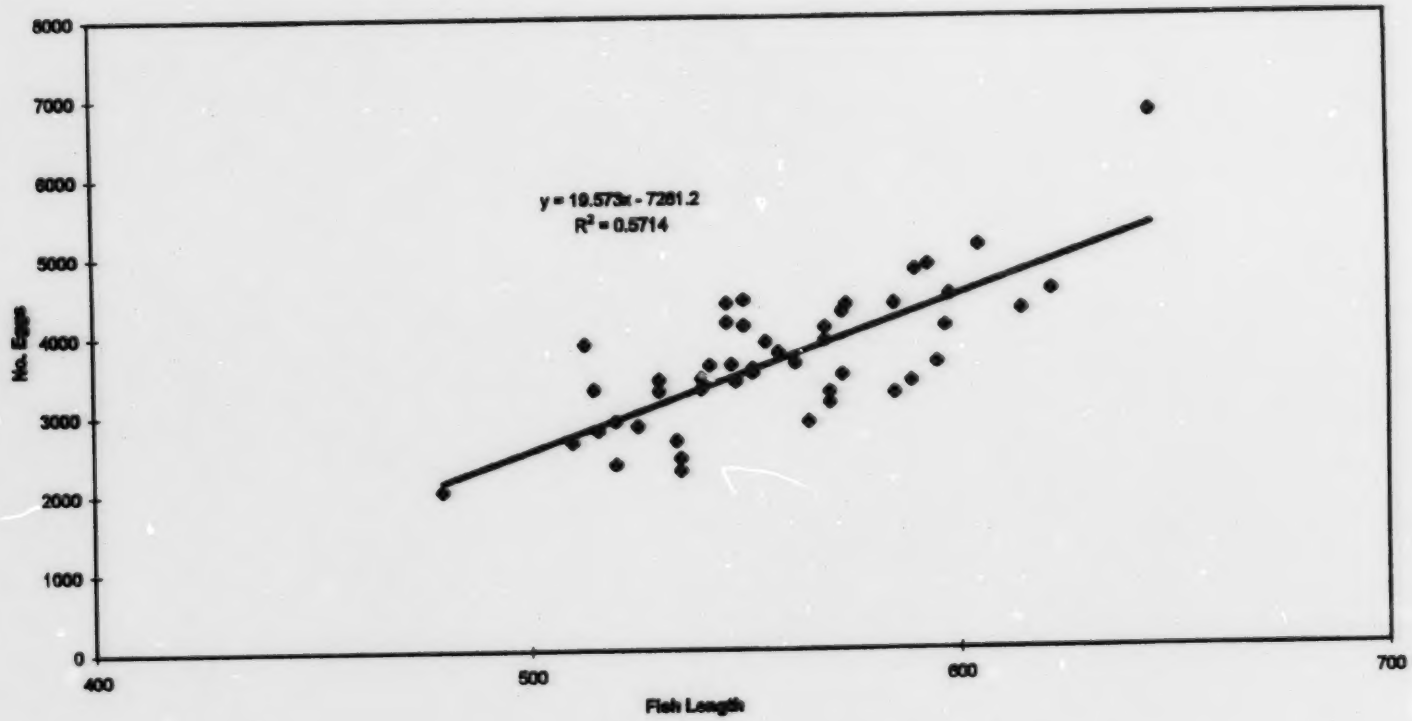

Figure 2. Fecundity relationship for Rocky River salmon.

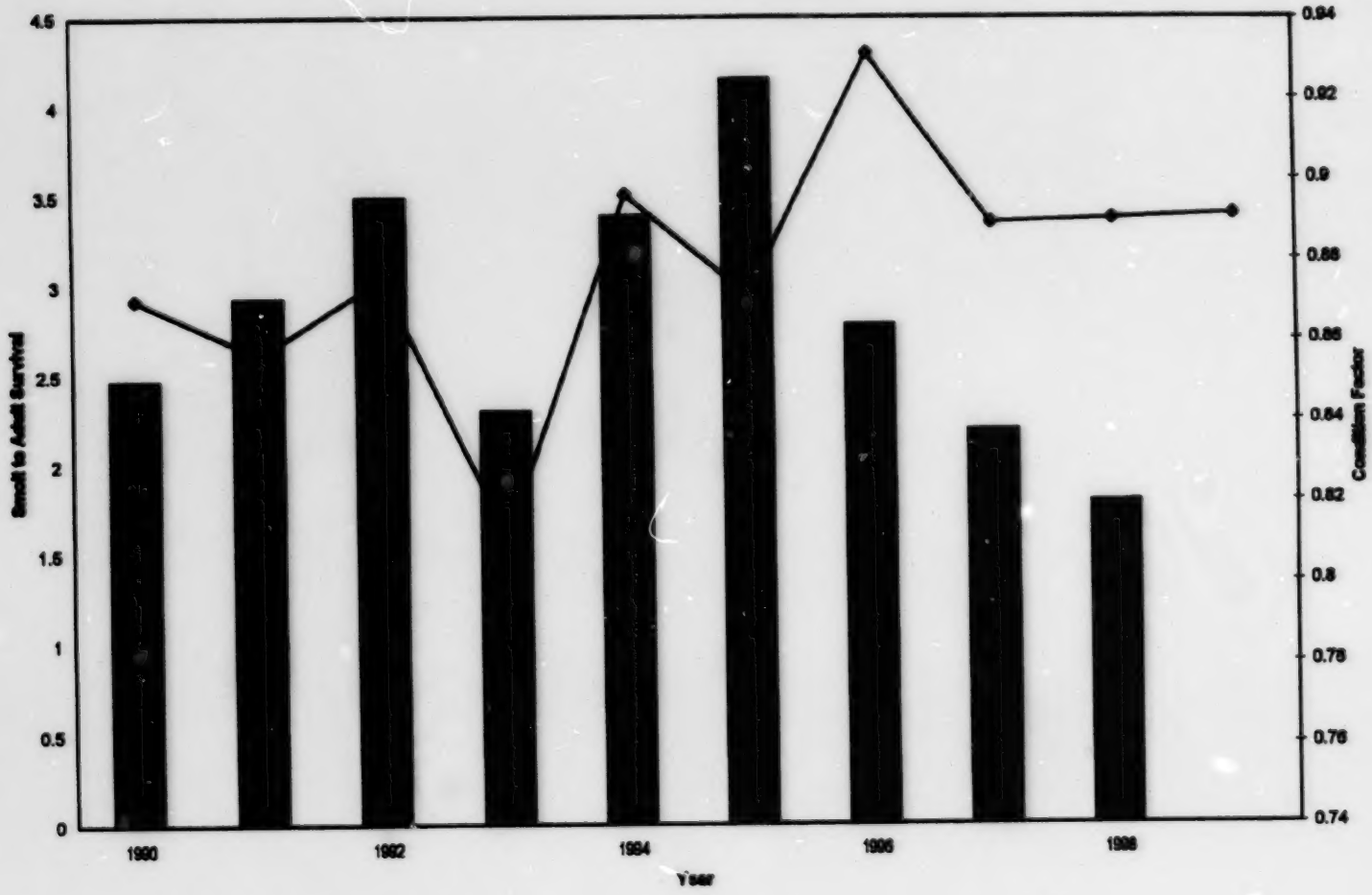

Figure 3. Smolt-to-adult (1SW) survival and relative condition factor of Rocky River smolt.

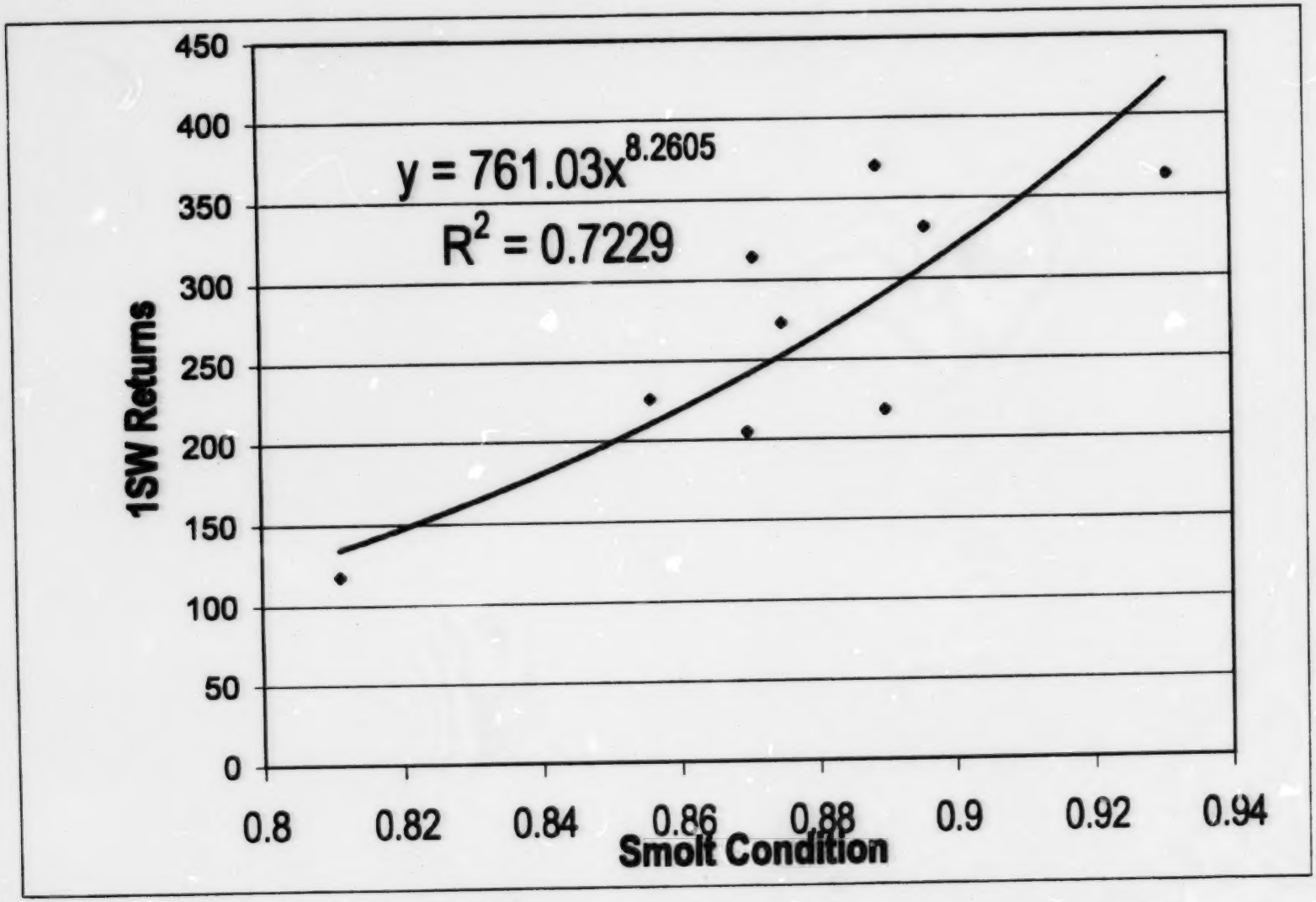

Figure 4. Smolt condition in year X versus 1 SW returns in year X+1.